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BLOOD VESSELS AND NERVES OF THE FACE IN RODENTS WITH AND WITHOUT CHEEK POUCHES

by

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TABLE OF CONTENTS

Page No.

I INTRODUCTION 1.

II LITERATURE 2.

- A. Facial vessels and nerves in Muridae 2.
  - 1. Facial arteries in Muridae 3.
  - 2. Facial veins in Muridae 9.
  - 3. Facial nerves in Muridae 12.
- B. Facial vessels and nerves in Leporidae 14.
  - 1. Facial arteries in Leporidae 15.
  - 2. Facial veins in Leporidae 17.
  - 3. Facial nerves in Leporidae 18.
- C. Cheek pouches in Sciuridae and Geomyidae 19.
  - 1. Musculature of the cheek pouch 21.
  - 2. Histology of the ground squirrel pouch 28.

III METHOD AND MATERIALS 30.

- A. Types of injections 30.
- B. Types of stains 32.
- C. Inductorium 36.

IV CRICETUS AURATUS 37.

- A. General description of the pouch 38.
- B. Musculature of the pouch 38.
- C. Facial arteries of the hamster 41.
- D. Facial nerves of the hamster 43.

E. Histology of the cheek pouch of the hamster 45.
V SUMMARY 47.
VI ABSTRACT 50.
VII FIGURES 56.
VIII BIBLIOGRAPHY 69.

LIST OF ILLUSTRATIONS

Page No.

Fig. 1 Arteries and veins of the head of the rat 56.

Fig. 2 Arteries of the head of a rat 57.

Fig. 3 Veins of the head of a rat 58.

Fig. 4 Nerves of the head of a rat 59.

Fig. 5 Extrinsic muscles of the ground squirrel pouch 60

Fig. 6 Histological structure of the cheek pouch of the ground squirrel 61.

Fig. 7 Facial arteries of the rabbit 62.

Fig. 8 Facial veins of the rabbit 63.

Fig. 9 Facial nerves of the rabbit 64.

Fig. 10 Extrinsic muscles of the hamster pouch 65.

Fig. 11 Facial arteries of the hamster 66.

Fig. 12 Facial nerves of the hamster 67.

Fig. 13 Histological structure of the cheek pouch of the hamster 68.

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INTRODUCTION

Very little is known about the anatomy and histology of the hamster cheek pouch and its relationship to the cheek pouches of the various members of the Rodentia. The purpose of the work on which this thesis is based is to describe the blood vessels and nerves in the face of the hamster, especially their relationship to the cheek pouch, and to compare the blood vessels and nerves of the hamster with those of other rodents.

The hamster is a rodent about five inches in length with a fairly large internal cheek pouch. This rodent has been extremely useful in experiments on reproduction and on hormone and vitamin deficiencies. It is convenient to work with hamsters as they are easy to breed and are adaptable for laboratory experiments.

This problem was undertaken at the suggestion of Professor Lutz. In view of the work on capillary circulation in the hamster cheek pouch being carried on in this laboratory (Fulton, Lutz, and Jackson 1946-1947), it was hoped that more exact knowledge of the gross anatomy of the blood vessels and nerves of the face of this type of rodent would be useful.

LITERATURE

The facial vessels and nerves in Muridae

The rat belongs to the family Muridae. In this country, there are the following species and subspecies of Muridae: *Rattus norvegicus*, the Norway or brown rat, *Rattus r. rattus*, the black rat, *Rattus rattus alexandrinus*, the roof rat, and *Mus musculus*, the common mouse. The albino laboratory rat is a variation of *Rattus norvegicus*. The Muridae, originating probably in India, were unknown to the ancient Greeks and Romans and traveled to other lands in ships; all found in this country have been introduced from Europe.

These Muridae are small, varying from seven to ten inches in length, being lightly built with a slender head and large ears. The average weight of the albino laboratory rat is about 551 grams. The rat has a thin scaly tail, which, according to Hamilton(1943), is longer than the body in the black rat and roof rat, but shorter than the body in the common mouse and about the same length as the body in the Norway brown rat. The body is covered with coarse fur mixed with longer, stiffer bristly hairs. The dental formula for the teeth is $\frac{1.0.0.3.}{1.0.0.3.}$. The molars of the Muridae are distinguished from Cricetidae by possessing three transverse series of tubercles. There are no cheek pouches in this family.

The Norway or brown rat is much more heavily built than the black rat and is grayish-brown dorsally with lighter fur on the underparts. *Rattus rattus alexandrimus* is commonly called the white-bellied rat or roof rat, being smaller than the Norway rat and having about 240 annulations on its tail, while according to Baird(1837), *Rattus norvegicus* has 200 annulations. *Mus musculus* is the common house mouse, being grayish-brown dorsally, and having a dull tinge on the belly.

Greene(1935) and Reighard and Jennings (1935) served as guides in dissection and for a description of the blood vessels and nerves of the face.

The facial arteries in rats

The arteries described below are illustrated in figures 1 and 2.

The right and the left common carotid arteries arise from the innominate artery and supply the head and neck regions. Each common carotid artery divides into an internal and an external branch. The latter begins at the level of the thyroid gland as a direct continuation of the common carotid. It immediately sends out five muscular branches to the neck. When it reaches the angle of the mandible, it turns dorsad at a right angle, and extends a short distance before it gives rise to a small branch, which passes dorsad to the ear. This branch is called the auricular artery.

As the external carotid artery passes dorsad, it first gives off the occipital artery above the bifurcation of the common carotid (fig. 2,4). Again the external carotid artery (fig. 2,1) turns at right angles near the dorsal margin of the masseter to divide into the internal maxillary artery (fig. 2,7) which passes craniad and becomes the superficial temporal artery (fig. 2,6). This supplies the deeper muscles of the neck and back of the head, and sends muscular branches to the M. stylohyoideus, M. digastricus, and M. cleidomastoideus.

The external maxillary artery (fig. 2,2) leaves the external carotid as the latter reaches the ramus of the mandible; it then turns sharply at an angle passing over the ramus, then ventrad to run forward along the boundary between the masseter and digastric muscles. At the anterior end of the latter muscle the facial artery crosses the mandible and appears on the lateral surface of the face, following the ventral margin of the masseter muscle. The artery then turns dorsad past the corner of the mouth. After forming the superior labial branch, it is known as the angular artery.

The facial artery has two main branches, the cervical and facial. From the former arise the glandular, tonsillar, submental, and masseteric arteries. The facial branch forms the following arteries: the cutaneous, the muscular, the inferior labial, the superior labial, the lateral nasal, and the angular.

The glandular artery consists of two vessels given off at the margin of the M. digastricus. One turns caudad to supply the submaxillary gland and the major sublingual glands. The other arises anterior to the submaxillary branch and turns caudad to supply twigs to the lymph glands of this region. It may arise with the submental artery.

The submental artery leaves the cervical branch of the external maxillary near the middle of the M. digastricus, sending a branch to the M. digastricus and M. mylohyoideus. It continues until it reaches the M. transversus mandibularis, the M. platysma and the integument of the submental region. The glandular branches may arise from the submental artery instead of from the facial artery. The anterior branches of the submental and facial arteries give rise to the masseteric aftery, which ramifies extensively through the masseter and anastomoses with the masseteric and buccinator branches of the internal maxillary artery.

The facial portion of the external maxillary artery may give off several cutaneous branches. The first arises as the external maxillary and crosses the mandible to supply the platysma muscle and skin of the midventral region. Another cutaneous branch arises between the inferior and superior labial arteries to supply the corner of the mouth.

The sedond branch of the facial portion of the external

maxillary arises as it crosses the upper margin of the mandible. It sends a branch into the mental foramen of the mandible, anastomosing with the inferior alveolar branch of the internal maxillary and also with a branch going to the lining of the mouth. It runs craniad along the mandible to the mucous membrane and muscles of the lower lip, sending out numerous branches. The inferior labial artery may arise with the muscular branch.

Between the inferior and superior labial arteries two large muscular branches are given off which may be called anastomotic branches. The dorsal branch arises below the superior labial artery at the level of the roof of the mouth and is directed dorsocaudad. This gives off a branch which turns craniad to supply the upper corner of the mouth. Continuing under the masseter which it supplies, it then reaches the roof of the mouth before anastomosing with the posterior superior alveolar artery. The second muscular branch arises with the inferior labial artery and is directed dorsocaudad, taking a deep course through the masseter and buccinator muscles. After supplying the lining of the mouth, it crosses the inferior alveolar ridge anterior to the ramus of the mandible, and anastomoses with the posterior superior alveolar artery.

The angular artery continues dorsad over the anterior

end of the zygomatic arch to the corner of the eye, which it supplies. It is the terminal portion of the external maxillary artery. In its course the angular artery gives off twigs to the M. levator labii superioris, the superficial portion of the masseter, and the mystacial pad.

The masseteric artery comes from the angle of the external carotid as the latter turns below the external auditory meatus. It runs cranioventrad for a short distance over the lateral surface of the masseter before ramifying into this muscle to supply it.

After the masseteric artery is given off, the external carotid artery gives rise to the anterior auricular artery, which arises between the temporal joint and the external auditory meatus. It is covered by the parotid gland at its origin and passes craniolaterad crossing the dorsal margin of the zygomatic arch. The auricular artery divides into two branches, one passing craniad to the exorbital portion of the lacrimal gland which it supplies; the other continuing dorsad to the anterior portion of the ear.

Greene(1935) states, "The external carotid artery turns craniad at right angles between the tympanic bulla and the neck of the mandible." After giving off the masseteric and anterior auricular branches, it divides into the superficial temporal and the internal maxillary arteries. The superficial

temporal artery gives rise to a masseteric branch which supplies the masseter, and also gives rise to a middle temporal branch supplying the M. temporalis. The superficial temporal in turn gives rise to the transverse facial artery, which follows the lower margin of the zygomatic arch supplying the masseter and the integument of that region. The last branch of the superficial temporal is the zygomatico-orbital, which divides almost immediately into the palpebral and the lacrimal branches. The palpebral artery supplies the intraorbital lacrimal gland.

The internal maxillary artery follows a deep course beneath the masseter muscle; it is one of the terminal branches of the external carotid beginning just in front of the temporo-mandibular joint. In the rat the mandibular and the pterygoid branches of the internal maxillary artery are not very distinct. The pterygo-palatine portion of the internal maxillary is taken over by the internal carotid artery, according to Greene(1935).

The internal maxillary artery first gives off the pterygoid branch which supplies the M. pterygoideus. Then it gives rise to the posterior deep temporal artery which runs dorsad to the M. temporalis. Passing craniad, it gives off the anterior deep temporal artery which crosses the neck

of the mandible beneath the posterior root of the zygomatic arch and sends an articular branch to the tempero-mandibular joint before entering the orbital fossa where it supplies the M. temporalis. Finally, the internal maxillary gives rise to the masseteric and buccinator arteries. Greene(1935) states that "the terminal branches of the internal maxillary which follow a deep course over the lateral surface of the mandible supply the deep masseter and buccinator muscles before anastomosing with the corresponding branch of the external maxillary."

The facial veins in the rat

The veins described below are illustrated in figures 1 and 3.

The supraorbital vein begins above the eye and communicates with the superficial temporal vein which begins on the frontal region of the skull. The supraorbital vein passes ventrad along with the angular artery past the anterior end of the zygomatic arch where it unites with the nasal and frontal veins to form the angular vein.

The angular vein is formed on the side of the face, a short distance in front of the corner of the eye. It follows the course of the angular artery ventrad as far as the corner of the mouth where it is joined by the superior labial to

to form the anterior facial vein. Before it joins the superior labial to form the anterior facial vein, it receives muscular branches from the masseter, M. levator labii superioris, and the vibrissal pad.

The frontal vein is a small vein which arises on the dorsal surface of the frontal bone; it joins with the nasal and supraorbital veins to form the angular vein.

The nasal vein starts with the terminal capillary branches of the nasal artery on the tip of the nose. It unites with the superior labial vein by means of the lateral nasal vein. The nasal vein continues dorsocaudad to join the supraorbital vein and the frontal vein forming the angular vein.

The anterior facial vein follows the course of the external maxillary artery, receiving tributaries corresponding to branches of the artery. This vein is a direct continuation of the angular vein, starting at the corner of the mouth. On the lateral surface it receives the superior labial vein and a muscular branch which takes its origin along the roof of the mouth and then runs cranioventrad through the masseter, receiving a branch from the corner of the mouth just before entering the anterior facial vein. The anterior facial vein also receives an anastomotic branch which begins in conjunction with the submental vein and then runs along the medial surface of the mandible to the anterior end of the alveolar

ridge. It crosses to the lateral surface and receives small branches from the lining of the mouth; then it opens into the anterior facial vein. The inferior labial vein emerges through the mental foramen and receives the mental vein. It connects with the inferior alveolar branch from the terminal capillaries of the internal maxillary artery. The submental vein and the masseteric vein enter the anterior facial vein below the mandible, receiving small glandular veins from the lymph nodes of the submaxillary region and the parotid gland. The anterior facial vein unites with the posterior facial vein to form the external jugular.

The external jugular vein in the rat is the principal vein of the neck. The vein forms along the boundary between the M. sternomastoideus and M. clavotrapezius and follows this boundary fairly closely. Proceding caudad very superficially through the cervical region, it crosses the clavicle and turns somewhat medially before uniting with the axillary vein to form the subclavian vein.

The superficial temporal vein has its origin on the frontal region of the skull where it communicates with the supraorbital branch of the angular vein. It passes caudoventrad behind the orbit where it receives the orbital vein. The orbital vein is made up of the palpebral and lacrimal veins from the upper lid and intraorbital lacrimal glands.

Just before it crosses the posterior root of the zygomatic arch, it receives the transverse facial vein and middle temporal vein. It then unites with the internal maxillary to form the posterior facial vein.

The internal maxillary vein arises in a deep position under cover of the M. temporalis and masseter; then it becomes more superficial in the space between the mandible and the tympanic bulla where it communicates with the inferior alveolar vein before continuing caudad to unite with the superficial temporal to form the posterior facial vein.

The masseteric and buccinator veins enter the anterior deep tamporal vein which passes caudolaterad over the condyle to empty into the internal maxillary vein.

The posterior facial vein is formed below the ear by the union of the superficial temporal and the internal maxillary veins. It first receives the anterior auricular vein which comes from beneath the exorbital lacrimal gland; it receives branches from the pterygoid externus and internus at the posterior end of the tympanic bulla. The posterior auricular vein passes down along the margin of the M. cleidomastoideus and M. sternomastoideus before entering the posterior facial vein. The latter meets the anterior facial vein to form the external jugular vein.

The facial nerves in rats

The nerves described below are illustrated in figure 4.

The facial nerve is the seventh cranial nerve. Kapper, Huber, and Crosby (1936) found that the facial nerve of the rat carries both special and general visceral sensory fibers. Greene (1926) states that the facial nerve arises from the brain stem at the anterolateral border of the medulla. It shows a swelling as it crosses the root of the trigeminal nerve which is the geniculate ganglion. Then it enters the facial canal, from which it emerges through the stylomastoid foramen.

As the facial nerve emerges from this foramen, it gives off a small branch, the digastricus, which runs cranioventrad to the M. digastricus of the jaw. The facial nerve also gives off a large branch, the posterior auricular, which turns dorsocaudad. Just before entering the pinna of the ear, it sends out three branches which supply the muscles of the ear and surrounding area.

As the facial nerve reaches the masseter, it turns craniad for about one half centimeter and then branches. The dorsal branch gives rise to two large nerves. The first is the temporalis, which turns dorsad and passes along the margin of the external ear supplying the superficial muscles of this region. Passing craniad to the M. temporalis, it then takes a deep position in this muscle, which it supplies. The

ventral nerve is the zygomatic, which divides into the upper zygomatic and buccal nerves. The former passes across the malar bone, supplying the eyelid and muscles around the eye with numerous branches. The buccal nerve runs along the dorsal border of the masseter, but does not come into contact with the ramus marginalis mandibulae nerve. The buccal and the ramus marginalis mandibulae nerves both send off branches to the lips and cheek before taking a deep position at the anterior part of the masseter.

The ventral branch of the facial nerve is the ramus marginalis mandibulae, which runs along the ventral border of the masseter. After passing craniad, it leaves the zygomatic-facial division of the facial nerve and gives rise to the small thin cervical nerve which supplies the still lower region of the masseter. The ramus marginalis mandibulae also takes a deep position at the anterior part of the masseter and passes to the mandible.

Facial vessels and nerves in Leporidae

The rabbit belongs to the family Leporidae. The incisors have a chisel-like edge used in gnawing and cutting; there are no canine teeth. The dental formula of the rabbit is $\frac{2.0.3.3.}{1.0.2.3.}$ making a total of eight teeth in the upper jaw and six in the lower jaw. The rabbit and the hare differ from all other

rodents by having four incisors in the upper jaw instead of two. The mouth is a small transverse slit with large lips which can easily be retracted, thus exposing the front teeth. The upper lip has a median cleft which divides it into a right and a left lobe.

The rabbit and the hare have large, long legs which are adapted for running and jumping. They have large ears and short tails which are covered with hair averaging about 4 cm. in length. The body is covered with fur which varies in color and thickness according to the species.

Crabb (1931) and Bensley (1910) were used as guides in dissection although both give very brief and inadequate descriptions of the blood vessels and nerves of the face.

The facial arteries in the rabbit

The arteries described below are illustrated in figure 7.

The external carotid artery passes craniad along the side of the neck and gives rise almost immediately as it makes its appearance through the muscles of the neck to the occipital and lingual arteries. The former turns dorsocraniad and passes to the posterior part of the base of the skull.

After the external carotid passes craniad for a short distance, it branches into the external and internal maxillary arteries. The former starts to turn ventrad immediately

and runs along the ventral border of the masseter, burying itself beneath the masseter and M. digastricus. It then emerges at the cranial border of the masseter where it gives off a masseteric branch which turns and runs slightly caudad supplying the cranioventral margin of the masseter. Next, the external maxillary artery gives off the inferior and superior labial arteries and the submental artery which supply the lower and upper lip and the chin respectively. This artery then turns dorsad and passes along the cranial border of the masseter giving rise to numerous small branches which supply the nasal region. It then gives off the angular artery which runs to and supplies the anterior margin of the eye.

The internal maxillary artery starts at the middle of the caudal edge of the masseter. Before it turns craniad, it sends off the auricular artery which passes dorsad to supply the ear and the surrounding area. The internal maxillary artery follows the margin of the masseter and gives off the transverse facial artery which turns ventrad and ramifies over the masseter to supply it. The internal maxillary also gives off the superficial temporal artery which turns dorsad and continues to the M. temporalis which it supplies. This artery also sends off a small branch to the eye; this branch is called the zygomatic-orbital artery.

The facial veins in the rabbit

The veins described below are illustrated in figure 8.

In the rabbit the facial veins follow much the same pattern as the arteries. The angular vein which comes from the margin of the eye passes ventrad and connects with the nasal, inferior and superior labial veins to form the anterior facial vein; this is a large vein which passes caudad along the same course as the external maxillary artery, starting at the ventral anterior margin of the masseter and passing beneath the ventral edge of the masseter and dorsal margin of the M. digastricus. Joining with the posterior facial vein beneath the stylomastoid foramen it forms the external jugular vein which runs caudad along the side of the neck.

The posterior facial vein (b) is formed near the base of the ear by the union of the superficial temporal and ophthalmic veins (j). The former turns ventrad and is joined by the transverse facial vein (e), which comes from the masseter and auricular veins (i), before entering into the formation of the posterior facial vein. The ophthalmic vein passes caudad from the margin of the orbit and turns ventrad before joining to form the posterior facial vein.

The facial nerve in rabbits

The nerves described below are illustrated in figure 9.

Crabb(1931) states that the seventh cranial or facial nerve leaves the brain with the eighth cranial nerve from the lateral side of the trapezoid body and emerges from the cranium through the stylomastoid foramen.

As it emerges, it gives rise to two nerves which run dorsocraniad and pass to the ear. These nerves are the anterior and posterior auricular nerves which supply the cranial and caudal sides of the ear respectively.

As the facial nerve passes craniad, it takes a horizontal position until it reaches the caudal margin of the masseter where it divides into three branches. The first branch, the mandibular nerve, turns ventrad and runs along the ventral margin of the masseter. At the cranial border of this muscle it ramifies into many small nerves supplying the upper and lower lips, the skin, and the chin. The buccal nerve,which arises at the same point as the mandibular nerve, is the second branch of the facial. The buccal nerve follows a middle course across the masseter. At the cranial border of this muscle it ramifies sending small branches to the upper lip. The third branch of the facial nerve is the zygomatic nerve which turns slightly dorsad and runs along the dorsal margin of the masseter. This nerve gives rise to

the zygomatic-orbital nerve which passes dorsocraniad to supply the eye region. As the zygomatic nerve reaches the cranial margin of the masseter it ramifies and its small brandhes supply the nasal region and muscles of the upper lip.

Cheek pouches in Sciuridae and Geomyidae

Within the family Sciuridae considerable variation exists in regard to the development of the cheek pouch. In the genera *Sciurus*, *Tamiasciurus*, *Glaucomys*, and *Pteromys* cheek pouches do not occur, but in *Tamias*, *Eutamias*, *Citellus*, *Cynomys*, and *Marmota* cheek pouches are found of varying degrees of anatomical differentiation. In *Cynomys* and *Marmota* the pouch may be described as rudimentary. Brandt(1901) pointed out that two kinds of cheek pouches can be distinguished among rodents. The first type consists of pouches which open upon the face outside the mouth and which are lined with hair. These are known as external cheek pouches and are to be found in the Pocket Gopher, *Geomys bursarius*, and other *Geomyidae* as well as in the *Heteromyidae*. The second type has the opening of the pouch within the vestibulum oris, so that when the pouch is closed, it is hidden within the lips. There are no hairs present in this type, which is an invagination of the inner surface of the cheek. This type is exemplified by the Sciuridae and Cricetidae.

The pouch and associated muscles in Geomys bursarius have been described by McChesney(1878), Osborn(1894), and Merriam(1895). Holliger(1916) described the extrinsic muscles of the pouch of Thomomys bottae, which exhibits many general resemblances to Citellus richardsonii in disposition of the extrinsic muscles. Holliger distinguished a levator muscle corresponding to that described for Citellus by Slegg(1926). Holliger also described a retractor muscle which originates upon the spinous processes of the last thoracic and first two lumbar vertebrae and a ventral retractor.

The family Geomyidae, comprising the mammals commonly known as pocket gophers, is confined to North America where it ranges from the plains of the Saskatchewan in Canada southward to Costa Rica. It is found best developed in the region of the Western United States and Mexico. The members of the family spend their entire lives underground, and they are modified in accordance with the need of a subterranean existence. Merriam(1895) states that all of the pocket gophers are provided with external cheek pouches. These pouches are used exclusively in carrying food and not in carting dirt as was often supposed. The cheek pouch reaches back as far as the shoulder and is so attached that it cannot be completely everted without the rupture of its connections. While the posterior part of the sack is held firmly by the muscle which stretches to the lumbar vertebrae, the skin of the inner side

of the pouch, which covers the face below the eye and in front of the ear, may be everted or prolapsed, hanging down as a flap below the corner of the mouth. This is probably what happens in the case of the snake fright, observed by Fisher(1893) who saw a gopher snake, Pituophis, about five feet in length hunting for breakfast. The snake glided into a gopherhhole, and presently the observer saw a gopher, Geomys lutescens, run out as fast as possible from the other end of the line of hills. When he caught up with it, it appeared very much frightened, and its cheek pouches were hanging out. The gopher evidently had only scented the snake, for it was apparent that the snake had not seen the mammal, since it came out of the hole by which it entered and glided off in another direction.

McChesney(1878) states that the aperture of the pouch is surrounded by a narrow delicate constrictor muscle, and that the long pouch itself, which extends back to the shoulder, is enveloped by a contractor muscle which seems to be a modified part of the platysma myoides. This muscle consists of two parts: (1) a retractor part, reaching from the extreme posterior end of the pouch backward over the muscles of the back and ending in a broad thin tendon which blends with the tendons of the superficial dorsal muscles, to be inserted into the spines of the last three lumbar vertebrae; (2) an anterior part which envelops the pouch proper; this latter

muscle is in turn subdivided into two parts: the external and internal regions. The former covers the upper or outer portion of the pouch and is inserted into the maxillary bone. The latter covers the inner and under sides of the pouch and is attached to the mandible. The uppermost fibers of this muscle join those of the retractor to be inserted on the upper jaw. The lower and inner surface of the muscle is thickest, the outer surface being thin and of little power.

Osborn(1894) described the muscles of the pouch as three distinct sets of muscles. First there is a circular muscle that runs along the margin of the pocket in its outer bounding fold. This, by its contraction, would seem to purse the opening of the pocket. The second set of muscles is that which he calls protractors of the pockets; these are two in number, one on each side of the pouch. They are spread out in the skin of both the inner and outer posterior portions of the pockets, and their fibers converge caudad to form somewhat definite bands. The outer fibers are attached to the skin at the origin of the fold on the upper jaw. The inner fibers are joined to the dorsal attachment of the fold at the lower jaw. These two muscles surround the pocket and their contraction pulls its recess forward to the opening of the vestibule. The third set of muscles is the retractors of the pocket. These arise funnel-wise from the surface of the pocket, both on its inner and outer aspects, and they run dorsocaudad

parallel to the fibers of the latissimus dorsi and totally free from the skin. They form a band three or four inches long and nearly an inch wide. Finally they are inserted in the tendinous aponeurosis that covers the insertion of the latississmus dorsi. They are attached to the neural spines of anterior lumbar vertebrae; these, by their action, retract the pockets.

Slegg(1926) states that the aperture of Richardson's Ground Squirrel, which possesses an internal pouch, is strongly crescentic and elongated posteriorly at the corner. The lips are densely clothed with hairs, and a hair-lined area extends inwardly into the vestibulum oris. On this area, which like the buccal mucosa is moist, the hairs are short and colorless and grow perpendicularly to the surface. Behind the incisors the upper lip is expanded mediad into a hairy pad, which projects into the mouth cavity across the anterior half of the diastema, and almost meets its fellow of the opposite side. On the medial edge of the hairy pad, and toward the roof of the mouth, is a smooth, white, hard patch of oval shape, two and one-half by one and one-half millimeters. This patch represents a cornified area of the inner face of the lips, and in its position of rest it presses slightly against the most anterior of the transverse ridges in the roof of the mouth. The two hairy pads, pressing together behind the incisors, form a partially enclosed

space large enough to hold a grain of wheat, which (it is surmised) is then pushed by the tongue into the cheek pouch over the oval, smooth pad, whose character is doubtless adaptive in relation to the act. At the corners of the mouth the inwardly facing hair-lined area of the lips bears a dense tuft of longer colorless hairs, which when the mouth is closed, projedt caudad, across the vestibulum oris to touch the first premolar.

The cheek pouches open into the vestibulum oris by a crescentic aperture behind the corner of the mouth and slightly ventral and posterior. The aperture is vertical and slightly in front of the first premolar; that is to say, it faces the cavum oris across the posterior position of the diastema. The pouch, when empty, is markedly flattened and oval-oblong in shape, extending back along the ventral or lateroventral surface of the head, between the skin and the masseter muscle, to the fascia of which it is closely applied, though not attached. The pouch measures from twenty-five to thirty millimeters in length and fifteen to eighteen millimeters in width. Its cubic capacity is, when distended, about 1.75 cc. When empty its lateral and medial walls are in cantact.

Slegg described the musculature of the cheek pouch as closely related to the superficial musculature of the face. Its development as a diverticulum of the vestibulum oris,

produced by invagination of the buccal ectoderm, has brought about extensive modification in the platysma muscle. It should be pointed out that considerable variation in the musculature was found in occasional specimens.

The pouch itself is invested everywhere with a layer of striated muscle, consisting of numerous loosely united fasciculi, running at various angles of inclination. The outermost fibers run mainly parallel to the longitudinal axis of the pouch. Thus, when the skin is removed from the head, the empty pouch resembles a flat muscle lying over the mandible and the masseter. When the pouch is distended the muscular investment thins out considerably, in some specimens more so over certain areas than others, as if the fasciculi had a tendency to group.

When the pouch is cut open and viewed from the inside, it is observed that, behind its opening into the mouth, the prevailing direction of the fasciculi is circular-wise, forming a broad imperfect sphincter whidh is especially compact along the posterior edge of the aperture. The muscular coat is thicker on the lateral side of the pouch than on the medial side.

The cheek pouch is supplied with a number of extrinsic muscles (fig.5). These are flattened bands, which may take origin a considerable distance away, and which are inserted loosely upon the muscular coat of the sac. The epimysium of

of the extrinsic muscle merges with that of the muscular investment.

Posteriorly, the cheek pouch has three large muscle bands inserted upon it, as follows: (1) A broad thin sheet of muscle inserted dorsolaterally, having its origin upon the middorsal raphe of the neck, where it adjoins its fellow of the opposite side. The fasciculi of this muscle tend to diverge away from the pouch into two bands of origin, the more posterior of which, in some cases, originates slightly more ventrad on the platysma of the side of the neck. (2) A somewhat stouter muscle band inserted on the lateral side of the pouch and having origin upon the acromion process of the scapula. (3) A muscle band, the fasciculi of which are fairly compact near their origin upon the sternum, but which diverge somewhat toward their insertion upon the medial side of the pouch into its posterior region.

It has been observed that the pouch has extrinsic muscles inserted on both its lateral and medial sides. From the acromion process a broad band of superficial muscle runs craniad along the ventral edge of the pouch, to which it may be attached loosely or not at all. It is inserted upon the skin of the lower lip in the thickening of the corium at the roots of the vibrissae. This band of muscle is connected to its fellow of the opposite side by a short band of transversely running fibers just behind the lower lips. The

insertion of the pair of muscles upon the lower lip is just outside, and in the lower region of, the orbicularis oris, which thus embraces the mouth of the cheek pouches. As an instance of the inconsistency of the extrinsic muscles, it was noted by Slegg that in one specimen the muscle on the right side was undeveloped in its distal half, arising from the lateral side of the pouch instead of from the acromion, and then preceding normally to its insertion upon the lip; on the left side the development was normal.

There is usually developed a slip of muscle running craniad from the lateral side of the pouch to the skin of the cheek. This muscle is inconstant as to position, size, and direction. Slips of muscle originate on the zygomatic arch and are inserted on the anterodorsal position of the lateral side of the pouch. If the posterior extrinsic muscles are cut, the pouch can be readily pulled aside and its medial side displayed up to its aperture. The region of the posterior edge of the aperture of the pouch is now seen to be thickened. In coronal section this thickening is ascertained to arise as a result of an increase in the corium of the angle and the development of numerous fasciculi. A small pad of cartilage lies in the angle, against the adjacent face of the masseter muscle. Upon this thickened area is inserted an extrinsic muscle, which runs back within the lining of the vestibulum oris above the upper gum to take origin upon the

fascia of the temporalis muscle. Occasional slips of muscle run from the maxilla to the medial side of the pouch, near its aperture.

Slegg described the microscopic anatomy of the cheek pouch as shown in fig. 6 . The cheek pouch is developed as an invagination of the mucosa of the vestibulum oris and shares the character of the mucous membrane of the mouth, except that there are no mucous glands present in the wall of the pouch. The mucous membrane of the pouch comprises a corium of areolar tissue, the bundles of which merge into the partitions of the epimysium of the muscular coat between the fasciculi. A basement membrane was not to be recognized; if it is developed it is thin and imperfect. The corium is overlaid by a fairly thick layer of stratified epithelium, more substantial than the mucosa of the mouth cavity proper, and approaching the skin in the amount of differentiation it exhibits. Although no stratum lucidum nor stratum granulosum is developed, the substantial character of the mucosa of the cheek pouch is doubtless in relation to the fact that the pouch is for the lodgment of hard, dry material, such as grains of wheat, which exert friction and pressure upon its lining, particularly under the contraction of the comparatively thick muscular coat and the action of the extrinsic muscle.The superficial scaly cells of the epithelial layer resemble closely in thickness and degree of keratinization the

stratum corneum of the outside skin. The aperture of the pouch, particularly its posterior border, is covered by a very compact and highly keratinized superficial layer, which is the more firm in that it exhibits no tendency to desquamation. That region is most highly subjected to friction when the seeds are pushed into the pouch by the tongue. The corium projects into the stratified epithelium in the form of vascular papillae, which are especially close together in the cornified region of the aperture.

METHODS AND MATERIALS

Various preliminary procedures had to be carried out before the animals were ready for studying. In general the animals were killed, embalmed, and injected; then they were ready for dissection.

Each animal was killed with chloroform. After the abdomen and thorax were cut open, the animal was injected with embalming fluid through the aorta. The aorta was reached by inserting a cannula through the ventricle. The embalming fluid used consisted of formalin 1.5 parts, phenol (melted crystals) 2.5 parts, glycerine 10 parts, and water 86 parts. By preserving the animals in such a manner, they could be injected at one time, and dissected at another.

Three types of injection mass were used. The first one consisted of starch containing yellow pigment. (Although yellow was used, any color could be substituted.) The formula used was starch 100 grams, chrome yellow 20 grams, formalin 150 c.c., glycerine 10 c.c. After the animal was killed, it was pinned down on a dissecting tray. The abdomen and thorax were shaved and then cut to expose the abdominal and thoracic cavities.

To inject the animal, a clamp was used to close off the aorta as it passes out of the heart. A small incision was then made in the left ventricle and a small cannula filled

with Ringer's solution was pushed into the left ventricle until its tip reached the interior of the aorta. To hold the cannula in place, a suture was tied around the aorta at the end of the cannula. The yellow starch mass was poured into a suction bulb having a tube attachment. The starch mass was forced into the cannula by means of a medicine dropper until all the air was removed. A tube with a suction bulb was attached to the cannula. The clamp was then removed from the aorta. By gentle pressure, arteries became filled with the yellow mass.

The reason this method is of no value in the study of the hamster is perhaps due to the fact that starch particles are too large to enter the small blood vessels.

A second type of injection mass was used with greater success. This is the Tandler blue gelatin mass, which is a cold fluid gelatinous substance described by Guyer(1936). To prepare this mass 5 grams of very fine gelatin is dissolved in 100c.c. of tepid distilled water. The amount of Berlin blue put into this solution is determined by the color shade desired, and then 5 to 6 grams of potassium iodide is slowly added. The mass remains fluid at ordinary temperatures, but when the injected objects are placed in 5% formalin, it sets completely and is thereafter unaffected by reagents. To preserve the fresh mass it is necessary to add a few crystals of thymol and keep the injection mass in a stoppered

bottle. The procedure for injection was the same as for the yellow starch injection mass.

The third injection mass was latex. Again the animal was opened and the blood vessels tied off. In the rabbit the external carotid artery was used to inject the blood vessels of the head. The procedure for inserting the cannula has been previously described. After the cannula was inserted into the external carotid artery, the animal was injected with the embalming fluid described above. After several days the embalmed animal is ready for injection. The colored latex mass was injected in the same manner as the embalming fluid. After 24 hours, the latex coagulated and the animal was ready for dissection. Hyman(1945) states that small vessels may be injected with a latex mass by diluting the latex with either ammonia water or distilled water.

There are five different types of procedures used for the histological study. First of these is the methylene blue method as described by Dr. Lutz. A Syracuse dish is partially filled with paraffin, which is allowed to harden. A square hole is then cut through the center of the paraffin. Xylol is used to clean out the paraffin from the bottom of the hole, so that there is no interference with the transmission of light.

The extrinsic muscle, which goes from the base of the pouch to the raphe of the back, was cut. It was kept moist

with Ringer's or saline solution. Then the pouch was stretched out over the hole and pinned in place. Two drops of 1% aqueous methylene blue were then added to the Ringer's solution. This gave the tissue a light blue color. The dish was then placed on the stage of an old microscope. The tissue had to be watched until the proper intensity of staining of the nerve fibers was reached. There were two steps in fixing the tissue. The first was to pour off the stain slowly and to rinse the tissue with Ringer's or saline solution. Saturated ammonium picrate solution was poured on and allowed to stand for one hour. When the stain became fixed, the tissue was cleared by pouring off the ammonium picrate and replacing with a solution of equal parts of ammonium picrate and glycerine. This was left standing until it cleared. In mounting the solution was poured off and replaced with pure white glycerine. The pins were then removed and the tissue was then transferred to a slide. Excess glycerine was disposed of by wiping the slide with clean cotton. A drop of glycerine was placed on the tissue. The slide had to be covered by a cover glass. The excess glycerine around the edges of the cover glass was removed by wiping it away with a moist squeezed-out piece of cotton. The edges of the cover glass were then sealed with paint.

The Golgi method as described by Guyer(1936) was used for the observation of nerve endings and plexuses in the

cheek pouch. In this method the preserved animal was taken from a 10% solution of formalin, which was used as a fixing agent. The extrinsic muscle which runs from the raphe of the neck to the pouch was then cut. The pouch was turned inside out and a terminal portion of about one centimeter was cut off. This cut-off portion was placed in 20 times its volume of 3.5% aqueous solution of potassium dichromate. It was necessary for the cheek pouch segment to remain in the solution for two days. After the first day, the old solution was poured off and a new solution of the same concentration put into the vial. When this process was completed, the tissue was transferred to a solution made up of the following constituents: silver nitrate crystals 1.5 grams, distilled water 200 c.c., and one drop of formic acid. The tissue was gently shaken in this solution until the brown precipitate of silver chromate ceased to appear; the tissue was then transferred into a solution having 20 times its volume of fresh silver nitrate solution. This was kept in a dark place for four days. For the best results in staining the cheek pouch, it is important that the solution be changed every 20 hours. The tissue was placed into a 95% solution of alcohol for a half-hour period; this solution had to be replaced once during this time. When this process had been completed, the tissue was placed into absolute alcohol solution for

one hour. It was then transferred to a solution containing 50% absolute alcohol and 50% toluol for one-half hour. After removal from this solution, it was placed in pure toluol until the tissue was cleared. After clearing it was immersed in half toluol and half paraffin mixture for one hour and placed in the parrafin oven until the toluol evaporated. In order that the tissue could rest in pure paraffin, it was necessary for the paraffin to be changed at least three times during the melting process. After the melting process had been completed, the tissue was embedded. From this embedded tissue fourteen serial slides were sectioned; some being sectioned at 10 microns and the others at 20 microns. The longitudinal sections were made at 20 microns; the cross sections were made at both 10 and 20 microns. The sectioned tissues were mounted with Haupt's solution(of egg albumin) in 3 per cent formalin. After the paraffin was dissolved a drop of balsam was placed on the tissue and a cover glass was added to make the slide permanent.

The pouch was also prepared for histological examination. This was accomplished by removing the pouch and fixing it in Bouin's fixative. When fixation was accomplished, the tissue was removed and carried through the various stages of alcohol. The tissues were cleared in xylol, embedded, and sectioned, Three different types of stains were used: Heidenhain's hematoxylin and eosin, Mallory's triple connective tissue

stain, and Heidenhains hematoxylin, eosin, and orange G.

To determine whether the buccal, zygomatic, and mandibular nerves supply the muscles of the cheek pouch, electrical stimulation was used. A standard inductorium was set up for a faradic circuit, using two 1.5 volt batteries. The secondary coil was placed at 12.5 cm. and at a forty-five degree angle. The electrodes used were made of fine copper wire which was curved into hooks to lift the nerves. The animal was anesthetized with nembutal. The skin was then removed from the back and face so as to expose the cheek pouch. The extrinsic muscles of the pouch were cut and the cheek pouch laid out so as to expose the nerves. The buccal nerve was then sutured proximal to the point of stimulation. The electrodes were then placed in contact with this nerve at about the middle of the masseter just ventrad to the eye. When the current was induced, contraction was observed in the cheek pouch. The experiment was repeated on the zygomatic and mandibular nerves. These nerves were stimulated just ventrad to the eye at points directly dorsad and ventrad to the first point of stimulation respectively. In this manner the innervation of the cheek pouch by these three nerves was confirmed as previously determined by dissection.

CRICETUS AURATUS

The cheek pouches of the hamster

The golden hamster (*Cricetus auratus*), a native of Syria, was first described by Waterhouse in 1839. According to Graves(1945), an adult female and its litter of twelve young were found in the vicinity of Aleppo, Syria, in 1930. They were bred in captivity at the Hebrew University of Jerusalem. In 1931, Dr. S. Adler carried some of the descendants of the original litter to England and presented two pair to Professor Hindle. From this colony has arisen the entire population which is now distributed to numerous laboratories abroad and in this country. The Cricetidae form an independent family of the Rodentia, although some writers, Weber(1927), for example, regard them as constituting a subfamily of the Muridae.

The golden hamster is a rodent about 12 cm. in length. It has large internal cheek pouches, about 5 cm. in length, which extend back to the shoulder. On the dorsal surface the hamster is orange-brown, and usually grey on the underside, but some European hamsters differ from this scheme of coloration. The circulation and nerves of the face and

cheek pouch have not been previously described.

Baird (1853) describes cheek pouches in another member of the Cricetidae, Peromyscus maniculatus gracilis, to which he refers as Hesperomys myodes, the hamster mouse. In this species of deer mouse the cheek pouch is not fully developed. It is not deep, although the walls show a high degree of contractility. They open on each side on a portion of the fleshy palate, which is situated between the incisors and the molars. The cheek pouch passes obliquely caudad.

The cheek pouch of the hamster is of the inner type, being developed as an invagination of the buccal ectoderm. There are no hairs present either in the pouch or around its opening. The medial side of the pouch lies against the masseter and is directed dorsocaudad, extending as far back as the shoulder. The lining of the pouch has numerous folds, similar in appearance to the rugae of the stomach, which enable it to expand when the pouch is filled with food. The cheek pouch is from 3 to 5 cm. long and about 1 cm. wide when empty. Food is passed into the cheek pouch or emptied from it through the use of the fore-feet.

Description of the musculature of the cheek pouch

The description of the musculature of the hamster as

given below is illustrated in fig. 10.

The musculature of the cheek pouch in the hamster differs from that of the ground squirrel, which also has an internal type of pouch. Only three extrinsic muscles were observed (Fig. 10). Two of these muscles originated from the same muscle band, which is attached to the last thoracic and first lumbar vertebrae. Almost immediately after it leaves this point of origin it splits into two muscles, the dorsal one being thicker and longer. The dorsal muscle is about 7 cm. long and passes craniad over the M. acromiotrapezious, M. clavotrapezius, M. sternomastoideus, and the masseter. The dorsal muscle (a) extends along the dorsal margin of the cheek pouch and is inserted near its base, i.e., its open end. The muscle is attached along the dorsal border of the cheek pouch by loose fascia. The ventral muscle (b), which is thinner, is about 5 cm. long. As it leaves the dorsal extrinsic muscle, it passes to the ventral border of the cheek pouch and is inserted on the ventral border about 1 cm. from the base.

The third extrinsic muscle (c) takes its origin on the fascia of the platysma muscle ventral to the ear, passes ventrad and then turns toward the cheek pouch and runs along its medial side. It is inserted at the medial ventral base of the cheek pouch.

These three muscle bands were the only extrinsic muscles found by the writer in relation to the cheek

pouch of the hamster; thus the caudal end of the pouch can be readily everted. In preserved specimens the dorsal and ventral extrinsic muscles give the appearance of being attached near the apex of the cheek pouch, and it is also probable that the muscles continue to insertions at the base of the pouch by means of long, transparent tendons. The writer has not yet been able to verify these attachments by histological methods. It is possible that the formalin, in which the preserved specimens were kept, caused the fascia to shrink and made it appear as if the extrinsic muscles were attached near the apex of the pouch. The extrinsic muscles are fairly adaptable to stretching; this enables the pouch to be everted. The pouch is held in position by fascia which is attached to the skin and the surrounding muscles.

The musculature of the hamster is different in many respects from that of the ground squirrel although their cheek pouches are of the internal type. In the ground squirrel there are six extrinsic muscles which are inserted on the cheek pouch, whereas in the hamster, three of these are lacking. In both animals one extrinsic muscle has its origin at the middorsal raphe of the back. The insertion of this muscle is different in each animal. In the hamster it divides into two muscle bands and is inserted at the base of the pouch. In the ground squirrel it arises as two bands which unite to form a single thick muscle which is inserted near the apex of the pouch on its dorsal margin. The median extrinsic muscle

in the hamster is not represented in the ground squirrel.

The facial arteries of the hamster

The arteries described below are illustrated in fig. 11.

The external carotid artery is the main source of blood supply to the face in the hamster. As the external carotid artery arises, it sends off numerous small branches which supply the M. clavotrapezius and M. sternomastoideus through which it passes. The external carotid artery (a) gives off a branch as it makes its appearance below the ear. This branch turns ventrad and is called the external maxillary artery (b).

As the external maxillary artery leaves the external carotid artery, it immediately passes ventrad without deviating from its course. When it reaches the inferior posterior corner of the masseter, it turns sharply in a craniad direction and becomes buried within the masseter at its junction with the M. digastricus. It reappears at the cranial border of the masseter where it sends out several branches. A cutaneous branch (c) is given off which carries the blood supply to the lips. This appears to correspond to the inferior labial artery described by Greene (1935) and Bensley (1910) as the branch which supply the lower lip of other mammals. By branching repeatedly, this cutaneous branch also supplies the area around the chin. The external maxillary artery then turns

craniad and sends off a long thin vessel which extends along the medial margin of the cheek pouch which it supplies (d). Upon the surface of the cheek pouch, it sends out a network of blood vessels. The external maxillary artery continues on its course dorsad, sending off numerous branches to the upper lip (e) and the nasal region (f), also giving off a muscular branch to the cranial edge of the masseter (o). The external maxillary turns caudad and becomes the angular artery (g) passing up to the eye.

Beyond the point of origin of the external maxillary from the external carotid, the latter turns dorsad and gives rise to the anterior auricular artery (h), which passes slightly dorsocaudad and extends to the ear, supplying the muscles of the ear. The external carotid artery then turns on the dorsocaudal margin of the masseter and becomes the internal maxillary artery (j). The internal maxillary artery is formed at the point at which the external carotid turns, and it continues to curve until it is level with the dorsal border of the masseter. As the internal maxillary artery curves, it gives rise to the masseteric artery (l) which passes ventrad diagonally over the masseter. When the masseteric artery reaches the middle of the masseter it branches and supplies the lower and middle area of this muscle.

The internal maxillary artery next gives off the superficial temporal artery (i). This artery turns craniad toward the M. temporalis, which it supplies. Before reaching the M. temporalis,

the superficial temporal artery gives rise to the zygomatic-orbital artery (k) which in turn supplies the surrounding area of the eye.

A third branch of the internal maxillary artery is the transverse facial artery (m) which turns ventrad upon the dorso-cranial border of the masseter which it supplies.

The facial nerves in the hamster

The nerves described below are illustrated in figure 12.

The seventh cranial or facial nerve (f) emerges through the stylomastoid foramen and takes a horizontal position before it appears through the muscles of the neck. As the facial nerve emerges, it gives rise to two branches. The dorsal branch, the posterior auricular nerve (e), turns slightly caudad and extends dorsad to supply the muscles of the caudal margin of the ear. The ventral nerve (n), called the digastricus, passes sharply ventrad until it reaches the margin of the lower jaw and turns to meet M. digastricus, which it supplies.

The facial nerve continues on a horizontal course until it reaches the caudal border of the masseter where it forms three branches. One branch (c) passes to the ventral border of the masseter and runs along its ventral edge until it reaches the cranioventral extremity of the insertion of the masseter where it ramifies, sending a small branch (k) to the ventral border of the medial side of the cheek pouch. This nerve is called the

ramus marginalis mandibulae; it also sends a small branch (j) to the chin and the lower lip. The branch (j) which goes to the lip and chin would correspond to the inferior labial and cutaneous nerves as described for the rat by Greene (1936).

The buccal nerve (b) is the middle branch of the facial nerve which turns slightly ventrad and runs across the lateral surface of the masseter about 1 cm. from its dorsal margin. When it reaches the craniodorsal extremity of the origin of the masseter, it unites with the zygomatic nerve (a) to form a thick nerve (o). Before this new nerve divides, it appears thicker than the facial nerve. This nerve was not found in the rat or rabbit, and will be named in a later paper. It is this new thick branch which gives off a branch to the nasal region and upper lip (h,i). The other branches of this thick nerve continue along a horizontal course until they reach the medial base of the cheek pouch where they turn caudad and run along the medial surface of the cheek pouch. Like the arteries, these branches form a network around the cheek pouch by repeated ramification.

The facial nerve gives rise to the anterior auricular nerve (d) which ascends dorsocaudad to supply the muscles of the cranial margin of the ear, before becoming the zygomatic nerve (a) which is the third major branch of the facial nerve. After giving off the anterior auricular nerve, the facial nerve continues as the zygomatic nerve which passes to the dorsal margin of the masseter and runs along its dorsal margin giving off the orbital nerve (g). It then joins the buccal nerve at

the cranial end of the masseter to form the thick branch previously described.

A description of the histological structure of the cheek pouch.

The slides used for the following observations were contributed by Dr. Fulton. The histological structure of the cheek pouch described below is illustrated in figure 13.

The wall of the cheek pouch of the hamster is about 392 microns in thickness, although it reaches approximately one half millimeter in places. This wall is composed of four layers which resemble the skin and oral mucosa of the animal.

The innermost layer is the mucosa and is made up of stratified squamous epithelium (a), which in places is undergoing desquamation. The stratified squamous epithelium is comparable to the corneum of the skin and is approximately 42 microns in thickness. The cuboidal cells (b) of the stratified squamous epitheleum, about 28 microns in thickness, correspond to the stratum germinativum of the skin. The stratified squamous epithelium and the lamina propria comprise the mucosa of the cheek pouch. Unlike the skin the stratum lucidum and stratum granulosum are absent in the mucosa of the cheek pouch.

The lamina propria (c), about 42 microns in thickness, is made up of closely packed connective tissue. The fibers of this connective tissue layer are closely packed and form nucleated bundles. There are no papillae present in the connective tissue, and it is comparable to the dermal layer of the skin.

Beneath the lamina propria is a muscular layer (d) which is about 182 microns in thickness. This layer is made up of bundles of striated muscle fibers, which are surrounded in places by a considerable amount of connective tissue. The extrinsic muscles are inserted on the outer surface of this striated muscle. The muscle fibers run parallel to the longitudinal axis of the cheek pouch. The apex of the pouch lacks muscular fibers.

The outer-most layer, which is a connective tissue layer (e), is made up of a loose network of areolar connective tissue which is about 149 microns in thickness. The connective tissue sheath around the striated muscle is continuous with this layer of areolar connective tissue. The areolar connective tissue was found to be very vascular, although a few vessels were also found in the lamina propria.

Unlike the skin, there are no glands present in the cheek pouch. There were nerve plexuses found in the lamina propria. This was the only layer that showed the presence of nerve plexuses. Some nerve endings were observed entering the striated muscle bundles of the muscular layer.

SUMMARY

Three extrinsic muscles were observed in the hamster; two of these, the dorsal and ventral extrinsic muscles, originate from the same muscle band. They are attached to the last thoracic and first lumbar vertebrae. The dorsal muscle extends along the dorsal margin of the pouch and is inserted near the base of the cheek pouch. The ventral muscle passes to the ventral border of the pouch and is inserted about 1 cm. from the base. The third extrinsic muscle takes its origin on the fascia of the platysma muscle ventrad to the ear. It is inserted at the medial ventral base of the pouch. The pouch is held in position by fascia which is attached to the skin and surrounding muscles. The musculature of the hamster cheek pouch is different in many respects from that of the ground squirrel as described by Slegg (1926), Merriam (1895), Osborn (1894), and McChesney (1878), although both pouches are of the internal type. In the ground squirrel there are six extrinsic muscles which are inserted upon the cheek pouch, whereas in the hamster, three of these muscles are lacking.

The cell structure of the pouch in the hamster differs from that of the ground squirrel. The mucosa in both pouches has a layer of stratified squamous epithelium which, in places,

is undergoing desquamation. It has been found that the stratum lucidum and stratum granulosum are absent in the pouch of both animals. The germinativum is present in both and is represented by the cuboidal cells of the stratified squamous epithelium. In the hamster, the epithelium is followed by a closely packed layer of connective tissue whose fibers form bundles. In the lamina propria of the hamster, no papillae are present; whereas Slegg described them in the ground squirrel. The lamina propria in the hamster is comparable to the corium in the ground squirrel as described by Slegg. In both animals, the pouch is invested with a layer of striated muscle, which is followed by a layer of connective tissue. The latter layer is composed of a network of areolar tissue which is absent in the ground squirrel. The wall of the hamster pouch is composed of four layers and is no more than .5 millimeter in thickness. The network of areolar tissue was found to be very vascular. Nerve plexuses were found in the lamina propria only, although some nerve endings were observed entering the striated muscle bundles. There were no glands present in any of the layers.

The cheek pouch of the hamster is surrounded by a network of blood vessels. The main source of blood supply is derived from the external maxillary artery, which gives off a small branch to the medial side of the pouch. This artery bfanches repeatedly over the surface of the cheek pouch.

The nerve supply to the cheek pouch is derived from three sources: buccal, zygomatic, and mandibular. The ventral border of the pouch is supplied by the mandibular nerve which runs along the ventral edge of the masseter muscle before giving off a branch to the chin and cheek pouch. The medial side of the pouch is supplied by the buccal nerve which unites with the zygomatic nerve to form a thick nerve at the cranial margin of the masseter. The dorsal border of the cheek pouch is supplied by the zygomatic nerve. This thick nerve branches, sending one branch to the nasal region and one to the dorsal and medial sides of the pouch. This innervation has been confirmed by electrical stimulation.

While the nerves in the rat, rabbit and hamster are similar in many respects, in the hamster, the buccal and zygomatic nerves combine to form a very thick nerve. This nerve then divides, sending one large branch to the nasal region and the other to the cheek pouch. This condition is not seen in either the rat or the rabbit. In the hamster, this nerve appears larger than the facial nerve before it ramifies at the caudal border of the masseter.

ABSTRACT

The purpose of this investigation is to present in detail the blood circulation and nerve innervation of the cheek pouch in Cricetus auratus, and the comparative gross anatomy of the blood vessels and nerves in the face of Muridae, Leporidae, Sciuridae, Geomyidae and Cricetidae, and to point out the relationship of these nerves and blood vessels to the muscles they supply. It is also the purpose of this paper to point out all similarities and differences in their structure from a consideration of the assembled data.

From the standpoint of comparative anatomy and histology, we have very little knowledge of the cheek pouch of the hamster. Pouches are well developed in some rodents and either poorly developed, present as vestiges or entirely absent in still others. In the literature, there is an extreme scarcity of detailed and accurate studies of the cheek pouch. In this paper, the blood vessels and nerves of the face in the rat and rabbit are described in detail. Greene (1936) served as a guide in the anatomy of the face in the rat, while Bensley (1910) was used for the anatomy of the face in the rabbit.

The pouches and associated muscles in Geomys bursarius have been described by McChesney (1878), Osborn (1894), and Merriam (1895). Holliger (1916) described the extrinsic muscles of the pouch in Thomomys bottae, which shows many

general resemblances to *Citellus richardsonii*. Holliger found the following extrinsic muscles in *Thomomys bottae*: a levator, a dorsal and a ventral muscle. Slegg (1926) described three extrinsic muscles inserting on the apex of the cheek pouch in *Citellus richardsonii*. Slegg also found that the cheek pouch is developed as an invagination of the buccal mucosa. The pouch itself is invested with a coat of striated muscle. The epithelial lining attains a degree of histological differentiation comparable to the outside epidermis, except that a stratum lucidum and stratum granulosum are not developed.

The methods of preparation for the study of the hamster pouch were as follows. The animals were all killed with chloroform. After the abdomen and thorax were opened by cutting through the anterior wall, the animal was injected with embalming fluid through the aorta. The aorta was reached by inserting a cannula through the ventricle.

Three types of injection mass were used. The first consisted of starch containing yellow pigment. This mass was of no value in the hamster. A more successful method was the Tandler blue gelatin mass, which is a cold fluid gelatin mass described by Guyer (1936). The third injection used was a latex mass, used only in the rabbit.

Five different types of stains were used. The first was the methylene blue method described by Professor Lutz. The Golgi method described by Guyer (1936) was used for the observation of the nerve endings and plexuses in the cheek

pouch. The pouch was also prepared for histological examination by fixing in Bouin's fixative, clearing in xylol and embedding in paraffin. Three different stains were used: Heidenhain's hematoxylin and eosin, Mallory's triple connective tissue stain, and Heidenhain's hematoxylin, eosin and orange G. stain.

To determine whether the buccal, zygomatic, and mandibular nerves supply the muscles of the cheek pouch, the nerves were stimulated with induced current. A standard inductorium was set up so as to produce a faradic current, using two one and a half volt batteries. The secondary coil was placed at 12.5 cm. and at a 45 degree angle. The electrodes used were made of fine copper wire.

A brief summary of the results obtained follows.

(1) The cheek pouch of the hamster is different in many respects from that of the ground squirrel as described by Slegg (1926), Merriam (1895), Osborn (1894), and McChesney (1878), although both animals have pouches of the internal type which are highly developed. In the ground squirrel, there are six extrinsic muscles which are inserted upon the cheek pouch; whereas, in the hamster, three of these muscles are not present. Two of the extrinsic muscles in both animals have similar origins, but their points of insertion are different.

(2) The histological structure of the pouch in the hamster differs from that of the ground squirrel. In the former, the mucosa was found to be composed of a layer of stratified squamous epithelium which, in places, is undergoing desquamation. It was found that the stratum lucidum and stratum granulosum are absent in the pouch of the hamster as well as in the squirrel. In the hamster, the epithelium rests on a closely packed layer of connective tissue, the fibers of which form bundles which are nucleated. In the lamina propria of the hamster no papillae were present, whereas they were found by Slegg to be present in the ground squirrel. The lamina propria of the hamster is comparable to the corium of the ground squirrel as described by Slegg. In both animals, the pouch is invested with a layer of striated muscles, which is followed by a layer of areolar tissue in the hamster but is absent in the ground squirrel.

In the hamster, the wall of the pouch was found to consist of four layers; stratified epithelium, lamina propria, muscular, and connective tissue, having a maximum total thickness of one half millimeter. The network of areolar tissue was found to be very vascular. Nerve plexuses were found in the lamina propria only, although some nerve endings were observed entering the striated muscle bundles. There were no glands present in any layer.

(3) In the hamster, the cheek pouch is surrounded by a network of blood vessels. The main source of blood supply

is the external maxillary artery, which gives off a small branch to the medial side of the cheek pouch. This artery branches repeatedly over the surface of the cheek pouch supplying it. The arteries of the hamster are similar to those of the rabbit and rat.

(4) It has been shown by stimulating the nerves electrically that the nerve supply to the cheek pouch is derived from three sources: the ventral border of the cheek pouch is supplied by the mandibular nerve; the medial and dorsal sides of the pouch are supplied by the buccal and zygomatic nerves which unite to form a hitherto undescribed nerve at the cranial border of the masseter. This large nerve gives off a branch to the nasal region and then passes craniad to the dorsal and medial side of the pouch. By repeated branching, the nerves form a network around the pouch.

(5) The nerves in the rat, rabbit, and hamster are similar in all respects but one: in the hamster, the buccal and zygomatic nerves combine to form a very thick nerve. In the rat and rabbit, this joining of the buccal and zygomatic does occur.

On the basis of the above data, it appears that:

(1) There are marked differences in the gross structure of the cheek pouches, which have attained the same degree of development in different species.

(2) The extrinsic muscles differ in origin and insertion in the hamster and the ground squirrel.

(3) The histological structure in both animals differs in many respects.

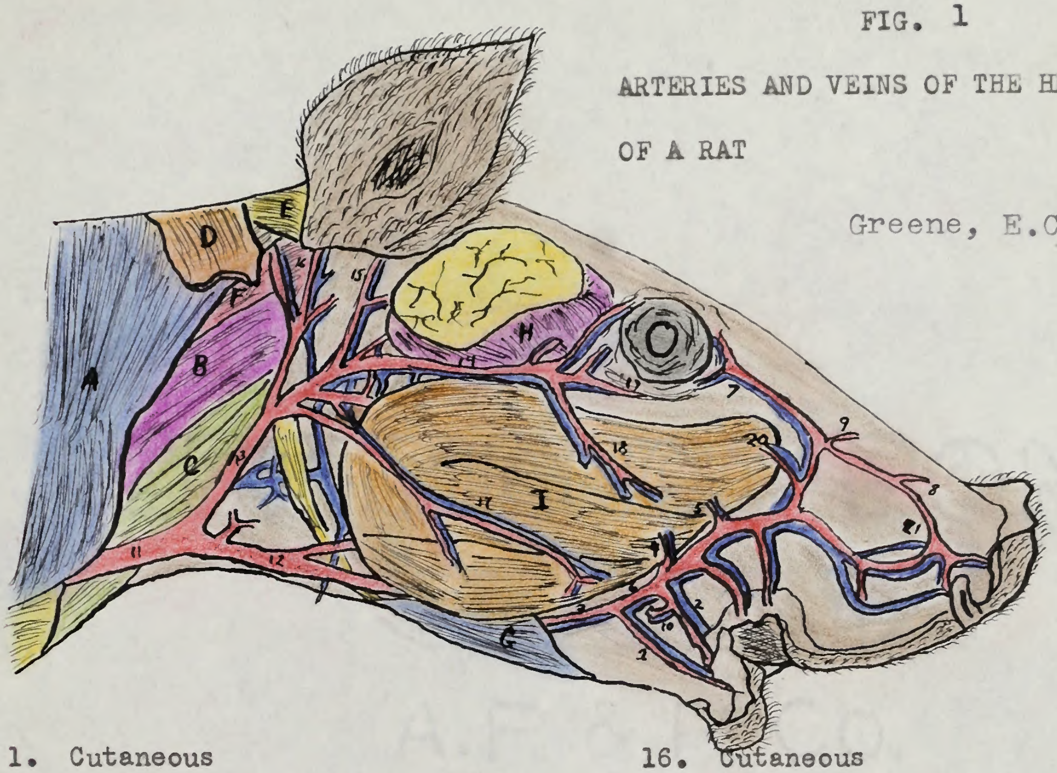
(4) The arterial system is similar in the rat, rabbit, and hamster except that the branch of the external maxillary that supplies the cheek in the rat and rabbit turns caudad in the hamster and supplies the medial side of the cheek pouch.

(5) The facial nerve is similar, in most respects, in the rat, rabbit, and hamster. However, in the rat and rabbit the buccal and zygomatic nerves do not unite. In the hamster, these nerves unite to form a new nerve which appears thicker than the facial nerve and supplies the nasal region, the upper lip, and the cheek pouch.

FIG. 1

ARTERIES AND VEINS OF THE HEAD OF A RAT

Greene, E.C. 1935



1. Cutaneous
2. Inferior labial
3. Anterior facial vein
4. To masseter and buccinator
5. To posterior superior alveolar
6. External maxillary artery
7. Supraorbital
8. Naso-frontal
9. Frontal
10. To lining of the cheek
11. External jugular
12. Anterior facial vein
13. Posterior facial
14. Superficial temporal
15. Anterior auricular
16. Cutaneous
17. Masseteric
18. Transverse facial
19. Inferior palpebral
20. Muscular
21. Lateral nasal

A. Spinotrapezious

B. Clavotrapezius

C. Sternomastoideus

D. Platysma

E. Levator auris longus

F. Splenius

G. Digastricus anterior

H. Temporalis

I. Masseter

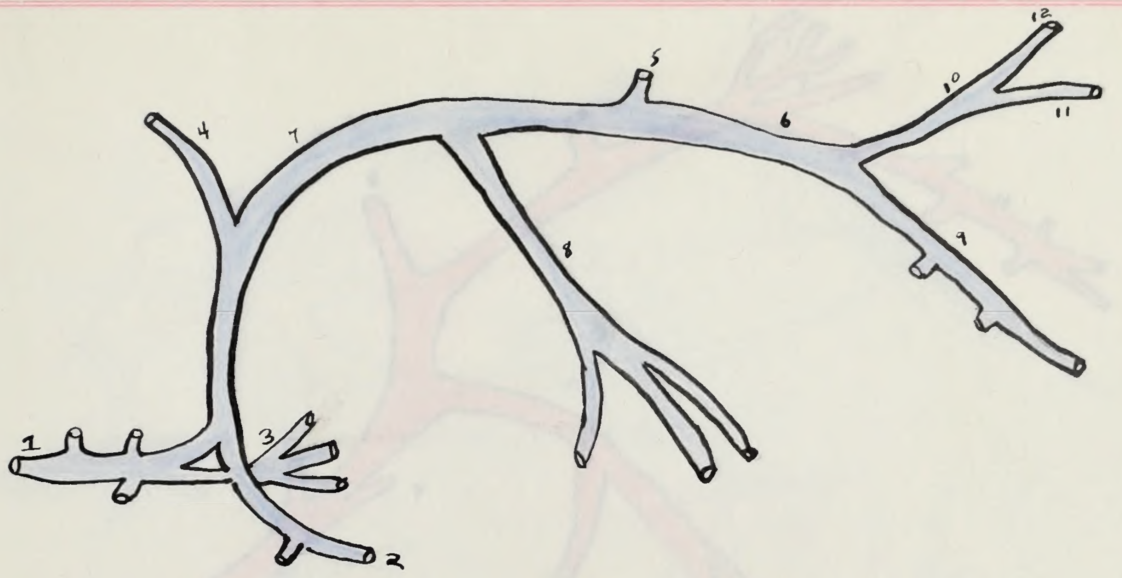


FIG. 2

ARTERIES OF THE FACE OF A RAT

Key To Fig. 1

1. External carotid
2. External maxillary
3. Lingual
4. Trunk common to occipital and posterior auricular
5. Anterior auricular
6. Superficial temporal
7. Internal maxillary
8. Masseteric
9. Transverse facial
10. Zygomatico-orbital
11. Lacrimal of middle temporal
12. Lateral palpebral

Greene, E.C. 1935

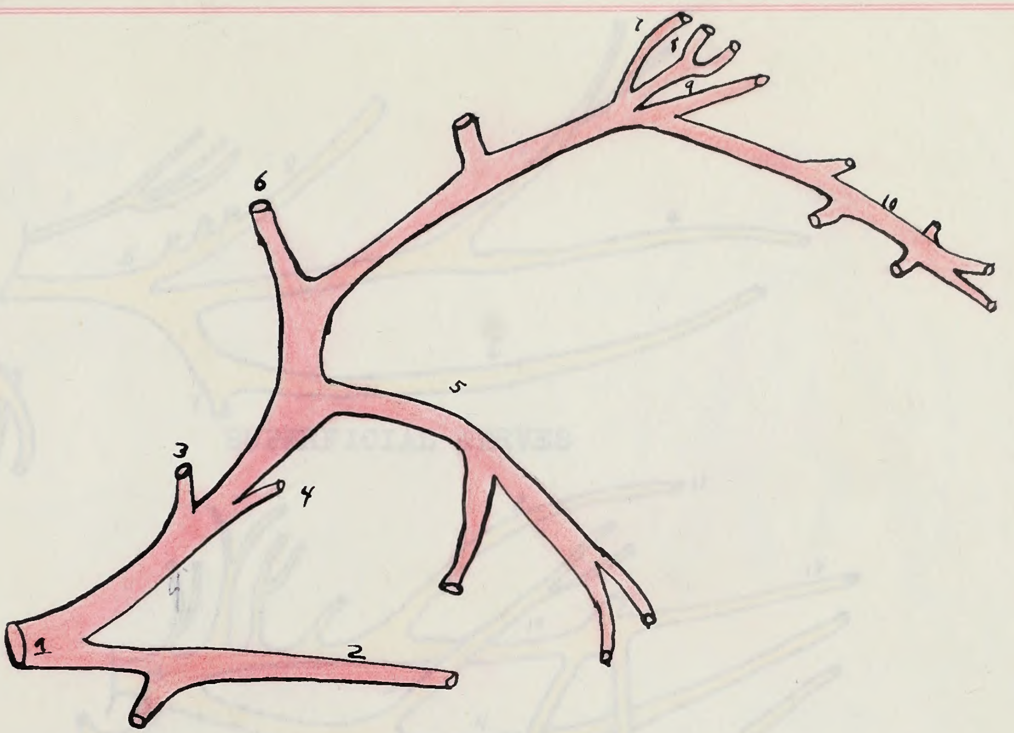


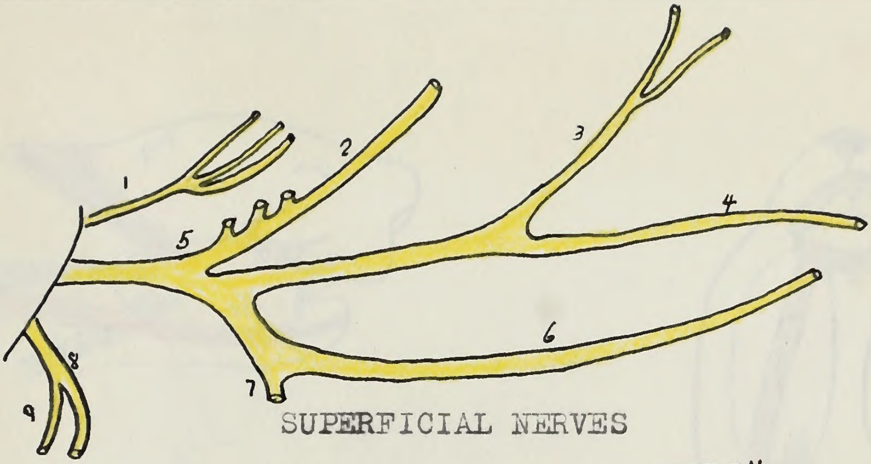
FIG. 3

VEINS OF THE FACE OF A RAT

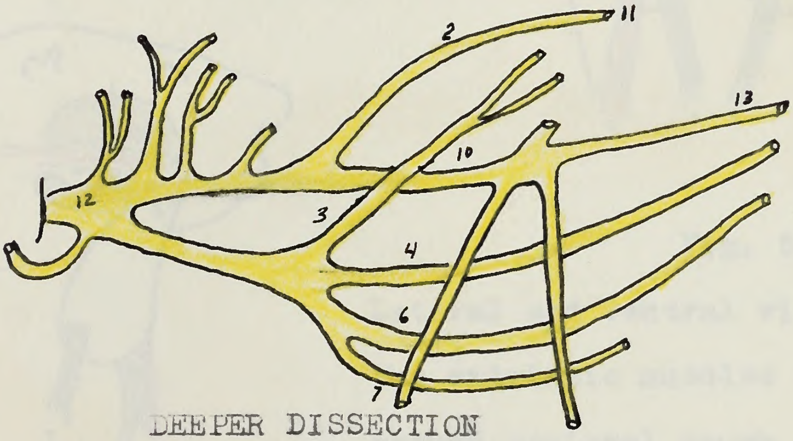
Key To Fig. 1

1. External jugular
2. Anterior facial
3. Trunk common to occipital and posterior auricular
4. Posterior facial
5. Masseteric
6. Anterior auricular
7. Superfical temporal
8. Middle temporal
9. Inferior palpebral
10. Transverse facial

Greene, E.C. 1935



SUPERFICIAL NERVES



DEEPER DISSECTION

FIG.4

BRANCHES OF THE FACIAL NERVE IN A RAT

1. Posterior auricular
2. Temporal
3. Upper zygomatic
4. Buccal
5. Zygomatico-facial division
6. Mandibular
7. Cervical
8. Stylo-hycid
9. Digastric
10. Lower zygomatic branches
11. To orbicular oculi
12. Temporo-facial division
13. To buccinator and muscles of the upper lip

Greene, E. C. 1935

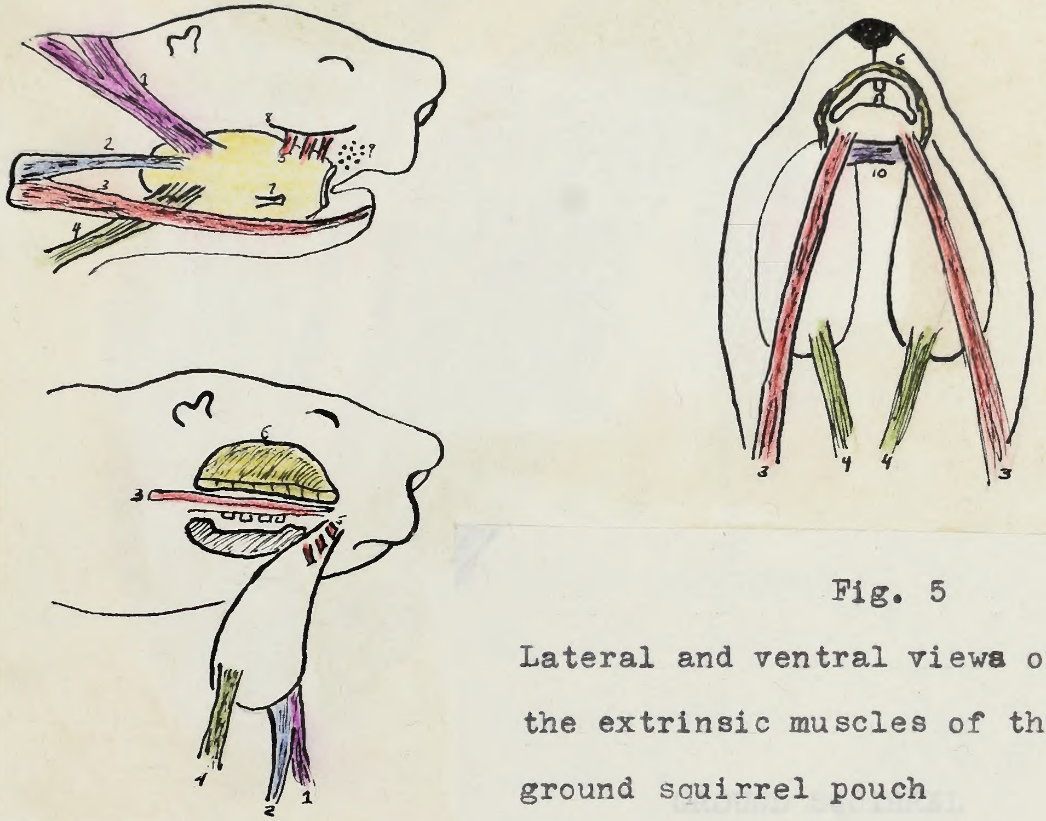
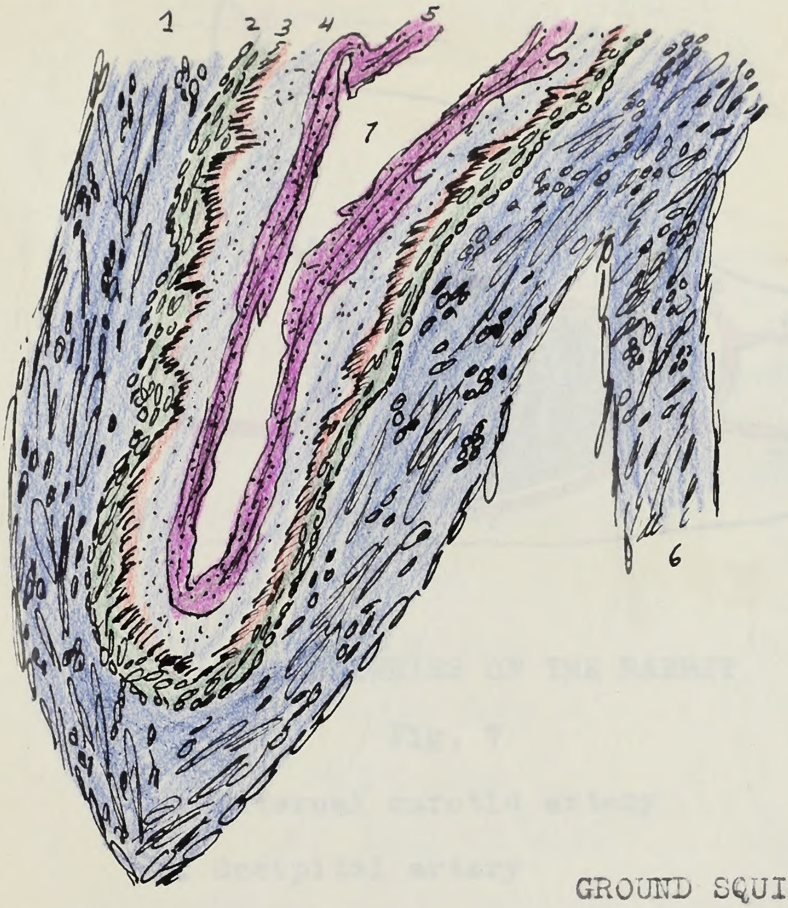


Fig. 5

Lateral and ventral views of the extrinsic muscles of the ground squirrel pouch

1. Origin middorsal raphe of the neck
2. Origin acromion process
3. Origin acromion process, insertion lip
4. Origin sternum
5. Origin zygomatic arch
6. Orbicularis oris
7. Origin skin of cheek
8. Zygomatic arch
9. Roots of vibrissae
10. Transverse band

Slegg, G.F.,1926



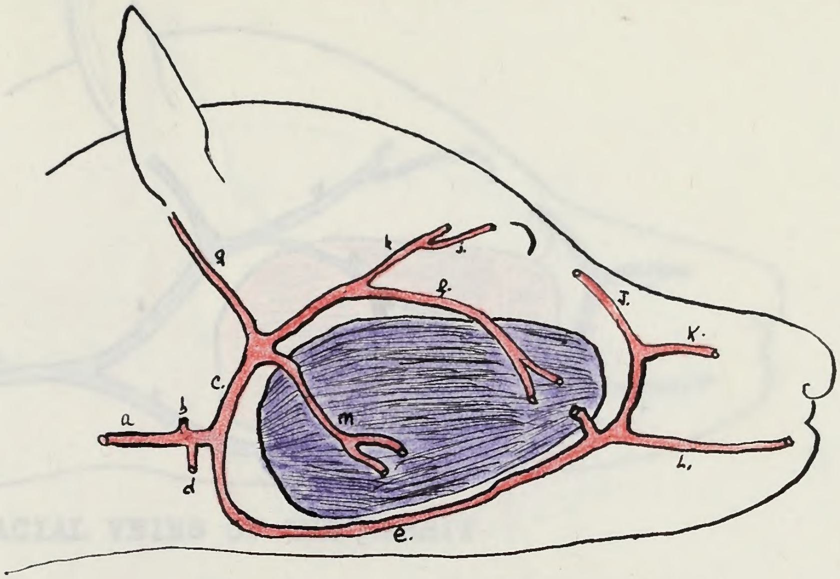
GROUND SQUIRREL

Fig. 6

Horizontal section through apex of cheek pouch, showing the insertion of an extrinsic muscle on its medial face

1. Investing layer of striated muscle
2. Corium
3. Basal layer of stratified epithelium
4. Rete mucosum
5. Superficial layer of epithelium, in places undergoing desquamation
6. Extrinsic muscle
7. Cavity of cheek pouch

Slegg 1926



FACIAL ARTERIES OF THE RABBIT

Fig. 7

a. External carotid artery

b. Occipital artery

c. Internal maxillary artery

d. Lingual artery

e. External maxillary artery

f. Transverse facial artery

g. Auricular artery

h. Superficial temporal artery

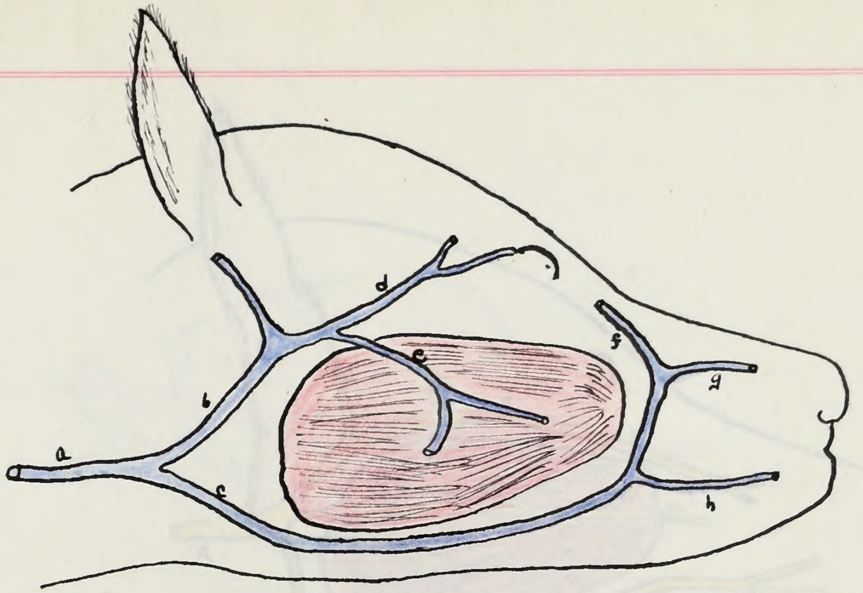
i. Zygomatic-orbital artery

j. Angular artery

k. Superior labial artery

l. Inferior labial artery

m. Masseteric artery



FACIAL VEINS OF THE RABBIT

Fig. 8

a. External jugular vein

b. Posterior facial vein

c. Anterior facial vein

d. Superficial temporal vein

e. Transverse facial vein

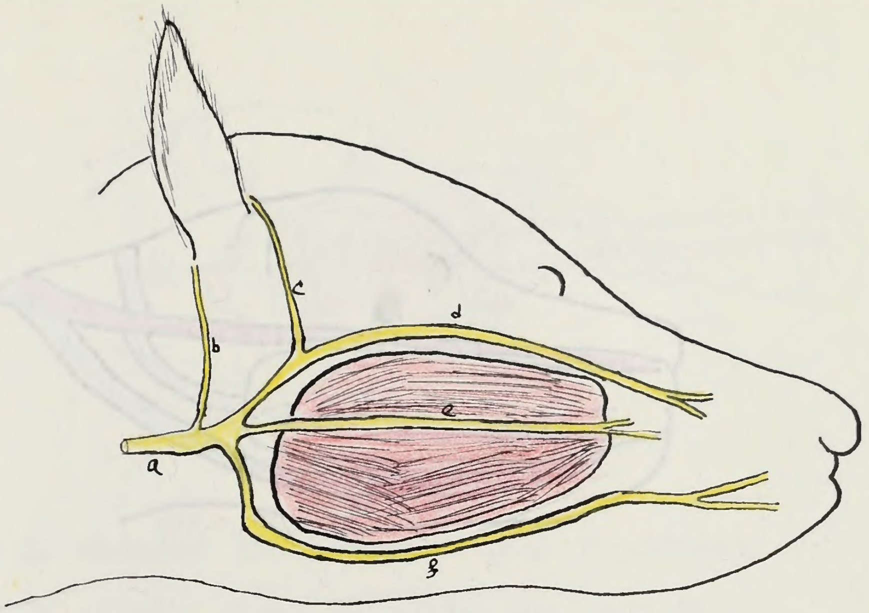
f. Angular vein

g. Superior labial vein

h. Inferior labial vein

i. Auricular vein

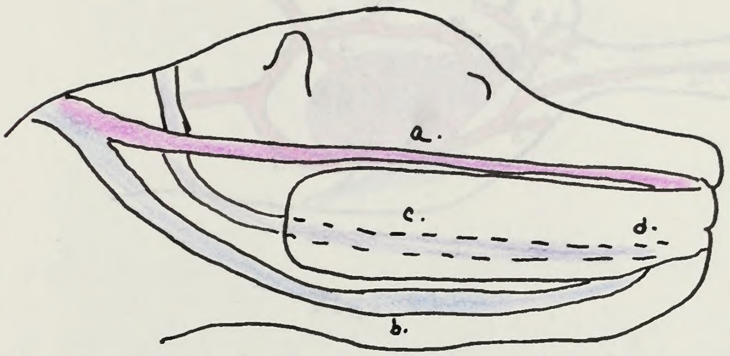
j. Ophthalmic vein



THE FACIAL NERVE IN THE RABBIT

Fig. 9

a. Facial nerve
b. Posterior auricular nerve
c. Anterior auricular nerve
d. Zygomatic nerve
e. Buccal nerve
f. Mandibular nerve



EXTRINSIC MUSCLES OF THE HAMSTER POUCH

Fig.10

a. Dorsal extrinsic muscle: origin on raphe of back, insertion upon dorsal border near base.

b. Ventral extrinsic muscle: origin on raphe of back, insertion upon ventral border of pouch one cm. from base.

c. Medial extrinsic muscle: origin on fascia of platysma muscle, insertion on medial side of pouch near base.

d. Base of cheek pouch.

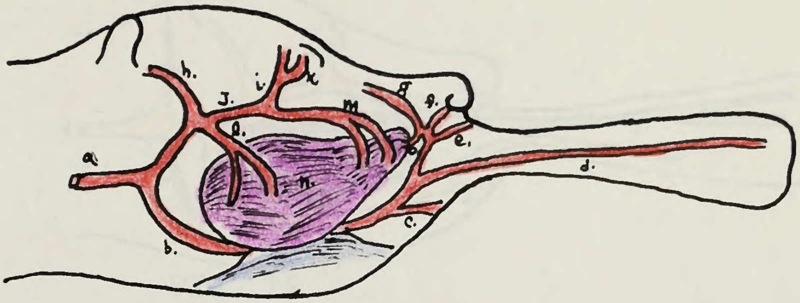


Fig. 11

Lateral view of the arteries showing medial side of the cheek pouch in the hamster

a. External carotid artery

b. External maxillary artery

c. Cutaneous and inferior labial arteries

d. Branch to supply cheek pouch from the external maxillary artery

e. Superior labial artery

f. Nasal artery

g. Angular artery

h. Auricular artery

i. Superficial temporal artery

j. Internal maxillary artery

k, Zygomatico-orbital artery

l. Masseteric artery

m. Transverse facial artery

n. Masseter muscle

o. Branch to cranial edge to masseter

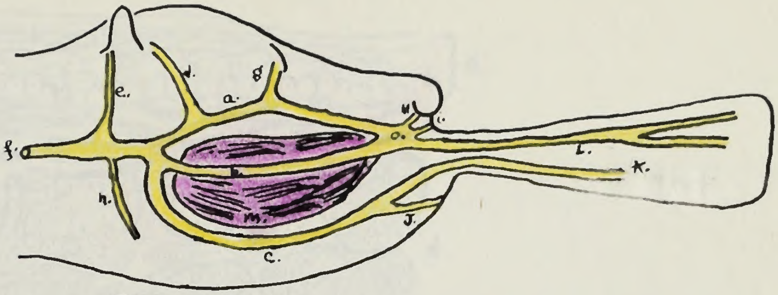


FIG. 12

Lateral view of the nerves showing the medial side of the cheek pouch

a. Zygomatic nerve
b. Buccal nerve
c. Ramus marginalis mandibulae nerve
d. Anterior auricular nerve
e. Posterior auricular nerve
f. Facial nerve
g. Zygomatico-orbital nerve
h. Branch to nasal region
i. Superior labial nerve
j. Branch of mandibular nerve to lower lip and chin
k. Branch of mandibular nerve to cheek pouch
l. Branch of buccal and zygomatic nerves to cheek pouch
m. Masseter muscle
n. Digastricus
o. Thick nerve formed by the buccal and zygomatic nerves

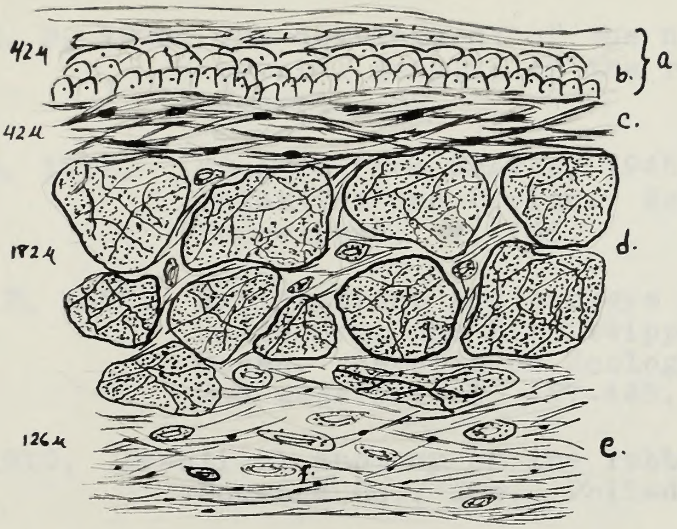


Fig. 13

Cross section showing histological

structure of the hamster cheek pouch

430 X

a. Stratified squamous epithelium

b. Cuboidal cells

c. Lamina propria

d. Striated muscle

e. Areolar connective tissue

f. Blood vessel

Drawn from a slide contributed by Dr. G. P. Fulton

BIBLIOGRAPHY

Adelman, H. B. 1925. The development of the neural folds and cranial ganglia of the rat. Jour. Comp. Neurol., 39.

Aharoni, B. 1932. (Quoted from Graves, 1945). Die Muriden von Palastina und Syrien. Zeitschr. f. Saugetierk. 7, 166.

Baird, S. F. 1857. Explorations and surveys for a railroad route from the Mississippi to the Pacific Ocean. Reports on Zoology, 33rd Congress 2nd session. 8, 427-445.

Bensley, 1910. Practical anatomy of the rabbit. P. Blakiston's Son and Co., Inc., Philadelphia. 93-94.

Brandt, A. 1901. Uber Backentaschen. Verhandl. Internat. Zool. Congress, Berlin. S. 598-600.

Bryant, H. 1913. Nocturnal wanderings of the California pocket gopher, Univ. of Cal. Pub. in Zool. 25-29.

Coues, E. 1875. The prairie gopher. Amer. Nat. 9, 147-156.

Crabb, E. D. 1931. Principles of functional anatomy of the rabbit. P. Blakiston's Son and Co., Inc., Philadelphia. 93-94.

Fulton, G. P., Jackson, R., and Lutz, B. R. 1947. Cinephotomicroscopy of normal blood circulation in the cheek pouch of the hamster. Science, 105, 361-362.

Flower, W. H. and Lydekker, R., 1891. (Quoted from Graves, 1945). An introduction to the study of mammals living and extinct. Adam and Charles Black, London. 461-477.

Graves, A. P. 1945. Development of the golden hamster Cricetus auratus Waterhouse during the first nine days. Amer. Jour. of Anat. 7, 219-237.

Greene, E. C. 1935. Anatomy of the rat. Transactions of the American Philosophical Society, XXVII.

Guyer, M. 1936. Animal micrology. University of Chicago Press, Chicago. 4th edition, 82-84.

Hamilton, W. J. 1943. The mammals of Eastern United States. Comstock Publishing Co. Inc., New York. 2, 349-357.

Holliger, C. D. 1916. Anatomical adaptations in the thoracic limb of the California pocket gopher and other rodents. Univ. of Calif. Publications in Zoology. 13, 447-494.

Hunt, H. R. 1924. A laboratory manual of the anatomy of the rat. The Macmillan Co., N. Y.

Hyman, L. 1942. Comparative vertebrate anatomy. The Univ. of Chicago Press, Chicago. 2nd edition, 534-535.

Kappers, C. U.; Hubber, C.; and Crosby, E., 1936. The comparative anatomy of the nervous system of vert. The Macmillan Co., N. Y. 1, 394-412.

Leitch, M. S. 1934. (Quoted from Greene, 1935). Embryology of the principal arterial vessels in the rat. (Unpublished manuscript).

McChesney, C. E. 1878. (Quoted from Merriam, 1895). Notes on mammals of Fort Sisseton, Dakota, U. S. Geol. Geog. Survey Terr. 4, 201-218.

Merriam, C. H. 1895. Monographic revision of the pocket gopher family Geomyidae. N. American Fauna, 8, 18-101.

Nelson, E. W. 1909. Rabbits of N. American. N. American Fauna. 29.

Osborn, H. L. 1894. (Quoted from Merriam, 1895). Notes on Geomys bursarius, the pocket gopher. Science 23, 102-103.

Parker, F. and W. Haswell, 1930. Text book of zoology. The Macmillan Co., N. Y. 5th edition, 481-587.

Potter, G. E. 1938. Text book of zoology. The C. V. Mosby Co., St. Louis. 1st edition, 587-593.

Pratt, H. S. 1935. Vertebrate zoology. Ginnand Co. 3rd edition, 292-293.

Reighard, J. and Jennings, 1935. Anatomy of the cat. Henry Holt and Company. 3rd edition.

Slegg, G. F. 1926. The cheek pouches of Richardson's ground-squirrel Citellus richardsonii Sabine. Jour. of Morph. and Physio. 41, 579-589.

Storer, T. I. 1943. General zoology. McGraw-Hill Book Company Inc. 1st edition, 712-714.

Tandler, 1936. (Quoted from Guyer, 1936).

Turtox Service Leaflet. The care and breeding of the golden hamster. 53.

Weber, M. 1928. (Quoted from Graves, 1945). Die Saugetiere Einfuhrung in die anatomic und systematik der recenten und fossilen mammalis. Fisher Company. 2nd edition.

Webster, C. L. 1897. The pocket and pouched gopher (Geomys bursarius). Amer. Nat. 37.

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